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Three new species of *Geodia* Lamarck, 1815 (Porifera, Demospongiae) from the bathyal depths off Brazilian coast, Southwestern Atlantic

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Three new species of *Geodia* Lamarck, 1815 (Porifera, Demospongiae) from the bathyal depths off Brazilian coast, Southwestern Atlantic. - This work comprises a taxonomic study of tetractinellid sponges from a poorly known region in the southwestern Atlantic, off the Rio Grande do Sul State coast, Brazil (31°05'–32°00'S/49°31'-50°00'W). Samples were collected by R/V "Atlântico Sul" of Fundação Universidade do Rio Grande in a continental slope survey ("Projeto Talude") and R/V "Prof. W. Besnard", of Instituto Oceanográfico da Universidade de São Paulo/Group for the Development of the Fisheries Industry, in Rio Grande do Sul I Cruise. Three new species are described: *Geodia australis*, *G. splendida* and *G. riograndensis*.

Key-words: Porifera - *Geodia* - Rio Grande do Sul - Brazil - taxonomy - continental slope.

INTRODUCTION

Six species of *Geodia* are registered for the Brazilian coast: *Geodia gibberosa* Lamarck, 1815 (Laubenfels, 1956), *Geodia neptuni* (Sollas, 1886, 1888 as *Synops neptuni*; Mothes, 1996), *Geodia tylastra* Boury-Esnault, 1973 (Boury-Esnault, 1973), *Geodia papyracea* Hechtel, 1976 (Hechtel, 1976), *Geodia corticostylifera* Hajdu *et al.*, 1992 (Hajdu *et al.*, 1992) and Geodia glariosa (Sollas, 1886, 1888 and Volkmer-Ribeiro & Mothes-de-Moraes, 1975 as *Cydonium glariosus*).

The present paper describes three new species dredged off Rio Grande do Sul State coast (31°05'-32°00'S/49°31'-50°00'W) (fig. 1), in the slope region (207 to 520 m depth), during oceanographic expeditions carried out by R/V "Atlântico Sul", of

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Fundação Universidade do Rio Grande, Projeto Talude; and by R/V "Prof. W. Besnard", of Instituto Oceanográfico, Universidade de São Paulo, in agreement with Group for the Development of the Fisheries Industry, in Rio Grande do Sul I Cruise.

The influence of the Subtropical Convergence, with marked seasonal latitudinal displacement, characterizes the southern/southeastern Brazilian continental shelf and slope regions (23°S-34°S) as a biogeographic transition zone (Mothes, 1996; Sharp, 1988) between the large neritic areas of Patagonia and tropical Brazil. The composition and abundance of species, the pelagic structure, the spatial distribution of communities and their trophic interactions, as well as biological production are largely controlled by the seasonal dominance of distinct water masses over shelf and slope. The studied material was collected in the summer period (october to april), when the influence of Tropical Waters is greatest, though waters of subantarctic origin may also rise during the summer along the southernmost shelf break regions.

The paratypes of *Geodia australis* sp. n. were collected between Sarita and Rio Grande localities, 101 Km off Rio Grande do Sul coast, with temperature of 14,50°C and salinity 35,76‰. The holotype of this species was collected between Mostardas and Solidão localities, 58 Km off Rio Grande do Sul coast. Temperature and salinity data for this sample are not known, as well as for the type-specimens of *Geodia splendida* sp. n. and *G. riograndensis* sp. n.

MATERIAL AND METHODS

The samples are deposited in the Porifera Collection of Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul (MCN/ FZB).

Abbreviations used are:

BMNH	Natural History Museum, London
MCN/FZB	Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, Brazil
MHNG	Muséum d'histoire naturelle Genève, Switzerland
UFRJ	Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil
ZMA	Zoölogisch Museum Amsterdam, Netherlands

The methodology used to prepare thick sections and dissociated spicules slides follow Mothes-de-Moraes (1978). Electron micrographs were taken at MCN/FZB with a Jeol 5200 equipment, with an accelerating voltage of 25 kV and magnifications varying from 1,500 to 10,000 times. Spicule measurements refer to minimum, *mean*, and maximum sizes in micrometers (μm) and were obtained by taking 50 measures of each type of spicule/specimen (unless stated otherwise).

DESCRIPTIONS

Order Astrophorida

Geodiidae Gray, 1867

Geodia Lamarck, 1815

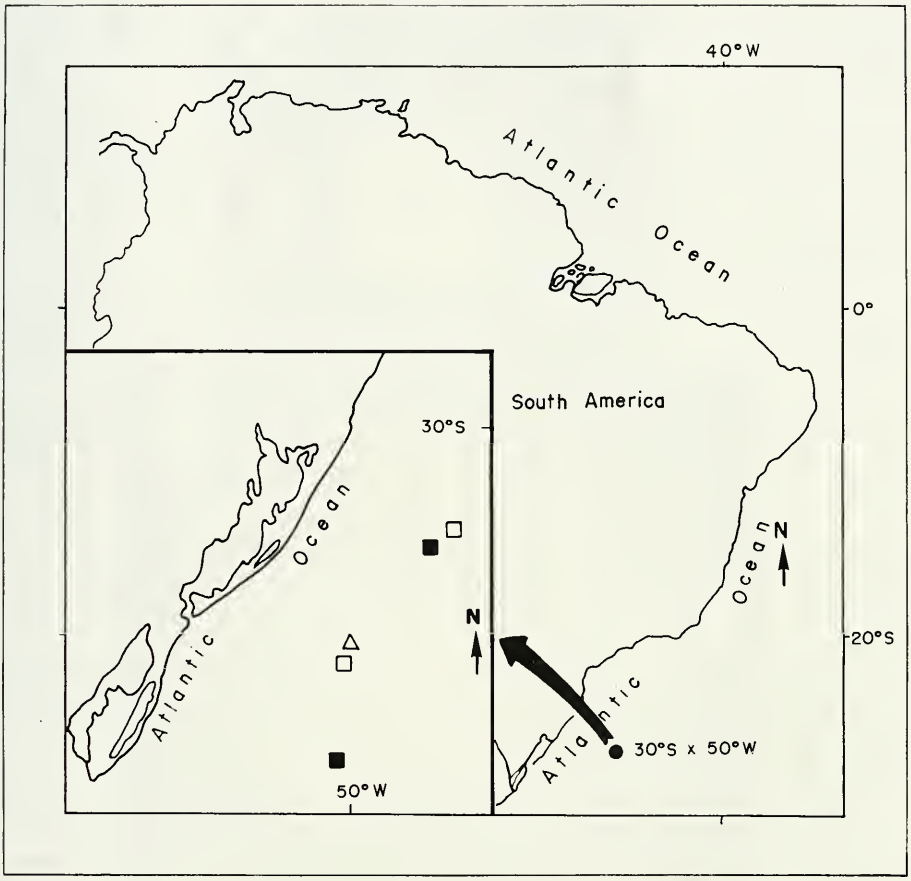


FIG. 1

Map of South American Coast with the Rio Grande do Sul State Coast in detail, showing the geographic distribution of *Geodia australis* sp. n. (■), *G. splendida* sp. n. (Δ) and *G. riograndensis* sp. n. (□).

Type-species: *Geodia gibberosa* Lamarck, 1815

Definition: Geodiidae with afferent and efferent aquiferous system independently, with well developed and large subectosomal spaces. Megascleres triaenes. Microscleres sterrasters and euasters of different types. Sterrasters varying from flattened or globose young forms, smooth with many spherical spaces or provided of conical and short rays, with blunt or strongiliform ends sometimes presenting small distal holes, to globose forms provided of star or rosette like microspinature at the distal end (adapted from Desqueyroux-Faúndez & Van Soest, 1997).

Geodia australis sp. n. Figs 1, 2, 5, 7, 11-26

Material: Holotype MCN 330, R/V "Prof. W. Besnard", off Rio Grande do Sul State coast, St. 458 (33°29'S/50°44'W), 9/XII/1968, 207 m, rocky substrate; Paratype MHNG-INVE

26564 (schizoparatype-slides deposited in the MCN 331), same data of the holotype; Paratype ZMA POR13418 (schizoparatype-slides deposited in the MCN 332), R/V "Prof. W. Besnard", off Rio Grande do Sul State coast, St. 444 (31°31'00"S/49°47'00"W), 6/XII/1968, 284 m, rocky substrate.

Description: Spherical sponge (fig. 2) (diameter 3.8 cm x 3.1 cm, height 2.8 cm). Hispid surface, with slight brushes of oxeas (fig. 7); small openings are observed in some points of the surface, which could not be differentiated in ostia or oscula. Colour in spirit grayish-white; compressible consistency. The sponges are associated with polychaets and corals.

Skeleton: Ectosomal (fig. 5): cortex (0.5 mm thick) with spherasters of variable sizes, over several layers of sterrasters ended at the cladome-layer of the dichotriaenes, plagiotriaenes and protriaenes; scattered small oxeas, strewn at random, are also observed.

Choanosomal (fig. 5): formed by dichotriaenes, plagiotriaenes, protriaenes and large oxeas, the last ones preferentially arranged in radial bundles, forming a right angle with the cortex. Besides the triaenes and oxeas, sterrasters, spherasters and oxyasters are abundantly spread.

Spicules: Oxeas I (fig. 12): fusiform, straight or slightly curved, with pointed or blunt ends; some with mucronate ends; length 1403-*2285.7*-3818/24-*31.0*-40 µm.

Oxeas II (fig. 13): fusiform, with gradually pointed ends; length 181-*275.1*-418/3.2-*4.8*-6.9 µm.

Dichotriaenes (fig. 11): conical rhabdom, with gradually pointed or strongyloid end. Cladi are first curved upwards and then slightly downwards; rhabdome 1012-*2246.0*-3565/33-*61.0*-86 µm; cladome 333-*553.8*-703 µm, protocladi 161-*192.1*-238/29-*38.7*-48 µm; deuterocladi 76-*107.2*-143 µm.

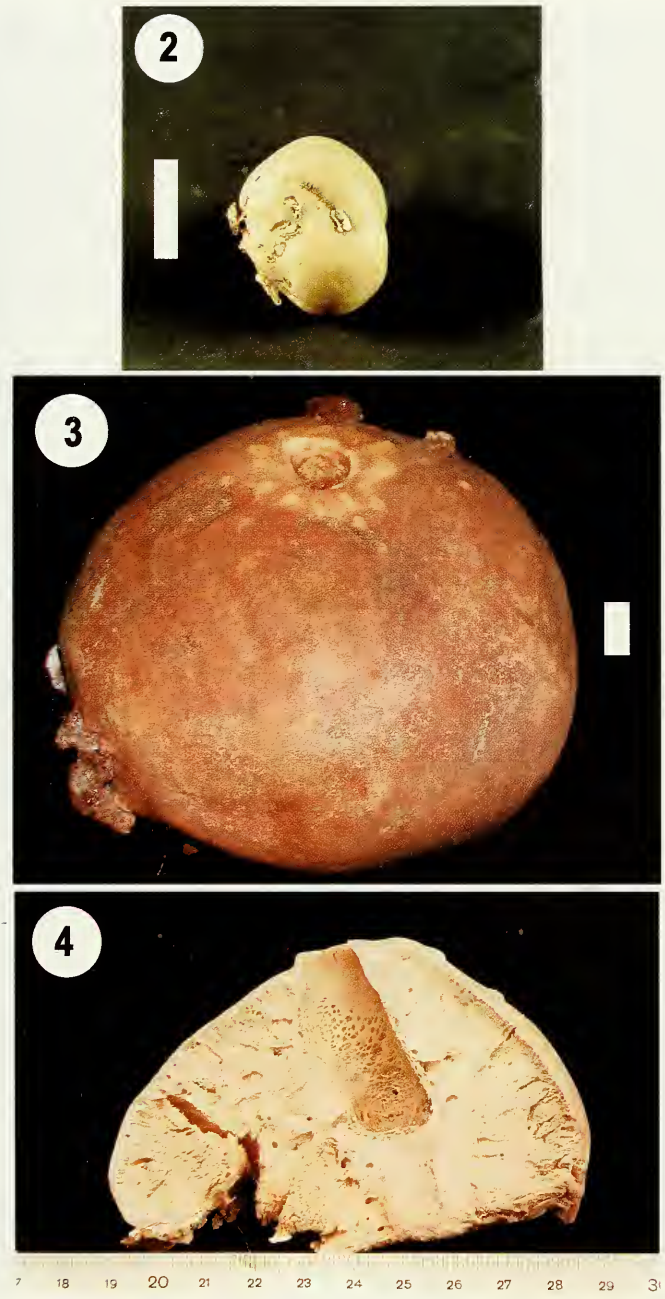
Protriaenes (fig. 17): conical, thin rhabdome, with gradually pointed or blunt end; cladi with thin ends, sometimes provided with a constriction; rhabdome 1334-*3143.9*-5865/4.6-*10.4*-23 µm; cladome 86-*154.2*-276 µm, cladi 67-*156.4*-276/4.6-*8.2*-14 µm.

Plagiotriaenes (fig. 16): rare (N=5), rhabdome conical, straight and thin, with gradually pointed end; cladi with thin ends; rhabdome 828-1909/19-28.5 µm; cladome 105-219 µm; cladi 51-131/11.5-18.4 µm.

Anatriaenes (fig. 14): rhabdome conical and thin, with pointed or strongyloid end; cladi with pointed ends, sometimes marked by a constriction; rhabdome 1150-*3450.0*-6140/4.8-*14.2*-24 µm; cladome 67-*130.9*-190 µm, cladi 48-*110.6*-181 µm. Some rares (N=5), slender and smaller anatriaenes (fig. 15) can be observed: rhabdome 323-423/3.4-4.6 µm; cladome 6.9-9.2 µm; cladi 2.3-4.6/1.1-1.8 µm.

Sterrasters (figs. 18-20): oval or more rarely spherical, the young scleres with microspined surface in the shape of pointed cones and in the shape of a star in adult scleres; diameter 266-*314.8*-352/190-*253.6*-295 µm.

Spherasters (fig. 21): spherical with well delimited center, variable size and short conical spines with blunt ends; in the choanosome, the largest spherasters can be taken for young sterrasters, differing by the shape of the microspines; diameter 20-*26.3*-32 µm.



FIGS 2-4

Habit: 2, *Geodia australis* sp. n.: 3, *G. splendida* sp. n.; 3, *G. riograndensis* sp. n.-inner view in transversal section. Scale = 2 cm.

Oxyasters I (fig. 22): small and smooth center; 4 to 7 long, conical and microspined rays; total diameter 35-*43.2*-52 µm, diameter of the centrum 2.3-*4.3*-6.9 µm, rays 9-*16.9*-25/1.5-*2.3*-3.5 µm.

Oxyasters II (fig. 23): small and smooth center: 8 to 11 long, conical and microspined rays; total diameter 16-*23.7*-32 µm, diameter of the centrum 2.3-*4.2*-5.8 µm, rays 6.9-*10.0*-13.8/2.3 µm.

Spheroxyasters (fig. 26): discrete center; 15 to 22 short , conical and scarcely microspined rays; total diameter 14-*16.1*-20 µm, diameter of the centrum 4.6-*5.7*-6.9 µm, rays 3.4-*4.5*-5.7/1.8-*2.2*-2.8 µm.

Spherostrongylasters: clear and smooth; 7 to 14 short, blunt rays, with conical microspines; total diameter 4.6-*7.0*-9.2 µm, diameter of the centrum 2.3-*2.8*-3.4 µm, rays 1.8-*2.3*-2.8/≤1.0 µm.

Etymology: The specific name refers to the type-locality, off Brazil's southern region [Latin word *australis* = southern; south].

Remarks: The samples utilized in this description were identified by Mothes-de-Moraes (1978) as *Geodia eosaster* (Sollas, 1886).

Hajdu *et al.* (1992) advanced the idea that *G. eosaster sensu* Mothes-de-Moraes (1978) could be a new species due to its widely disjunct distribution when compared to the original record of *G. eosaster* from Australia (Sollas, 1886; 1888). Our reexamination of Mothes-de-Moraes (1978) specimens, when compared with the syntype of *G. eosaster* [BMNH 1889.1.1.87], revealed several spicular micrometric distinctions and the SEM analysis confirmed the presence of adittional categories of megascleres and microscleres. We thus described them as *Geodia australis* sp. n.

Both species share the presence of dichotriaenes, protriaenes, spherasters and strongylasters, but they can be distinguished by the occurrence of rare plagiotriaenes, oval shaped sterrasters, and of a second type of oxyaster in the new species.

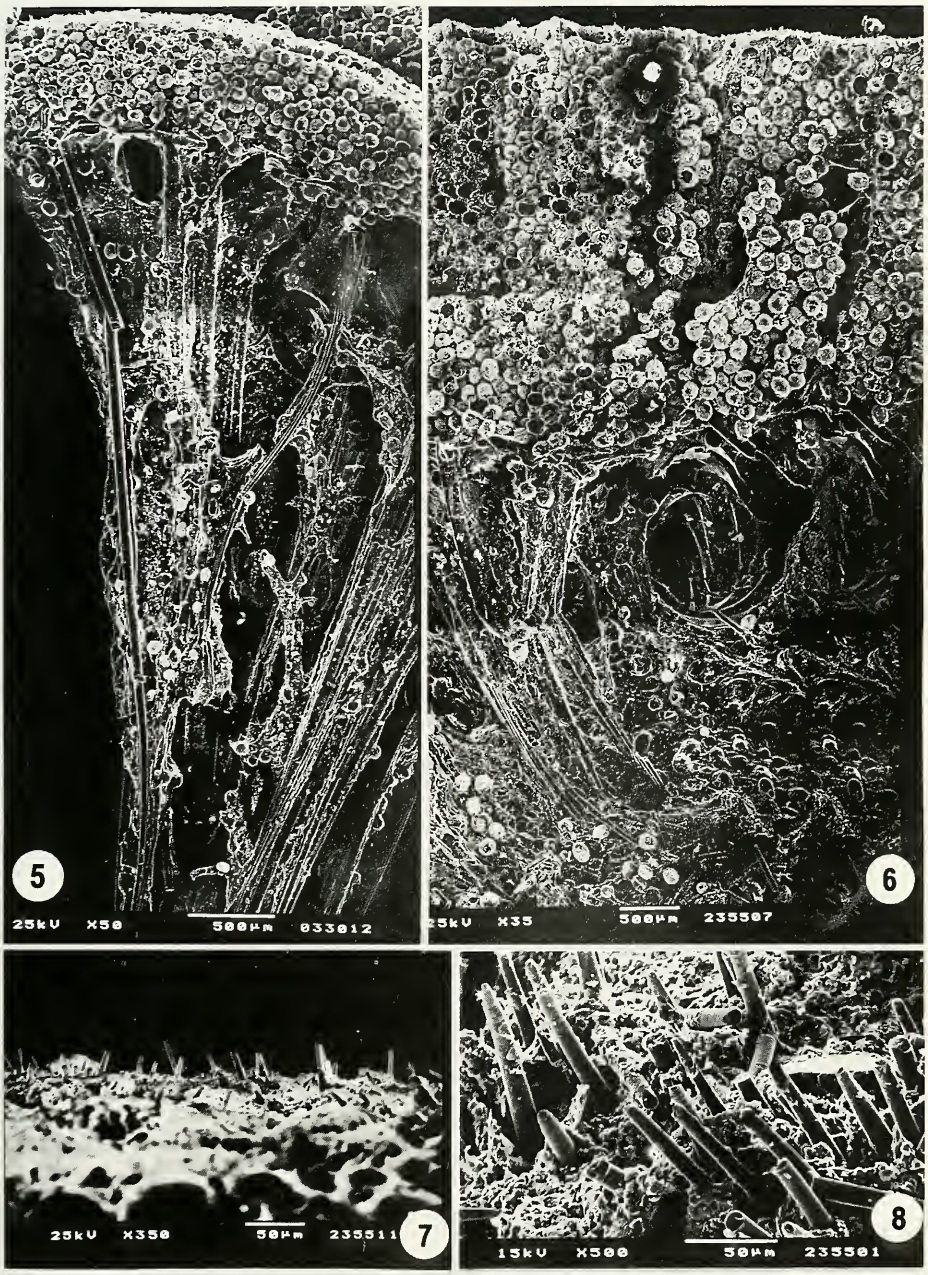
From the Tropical western Atlantic records of *Geodia*, the new species appears closest to *G. spherastrea* Lévi, 1964, from deep-waters off Puerto Rico, at 2840 m depth. Both species share the presence of dichotriaenes, protriaenes, anatriaenes, spherasters and strongylasters, but can be distinguished by the occurrence of rare plagiotriaenes, oxyasters and oval shaped sterrasters in the new species.

The "somal" spherasters of *Geodia eosaster* (Sollas, 1886) and the chiasters [=strongylasters *sensu* Boury-Esnault & Rützler, 1997] of *G. spherastrea* (Lévi, 1964), correspond to the spherostrongylasters here described for *G. australis* sp. n. The term was coined for cases where the width of the aster's centrum exceeds 1/3 of the microscleres total diameter.

Geodia splendida sp. n. Figs 1, 3, 6, 8, 27-39

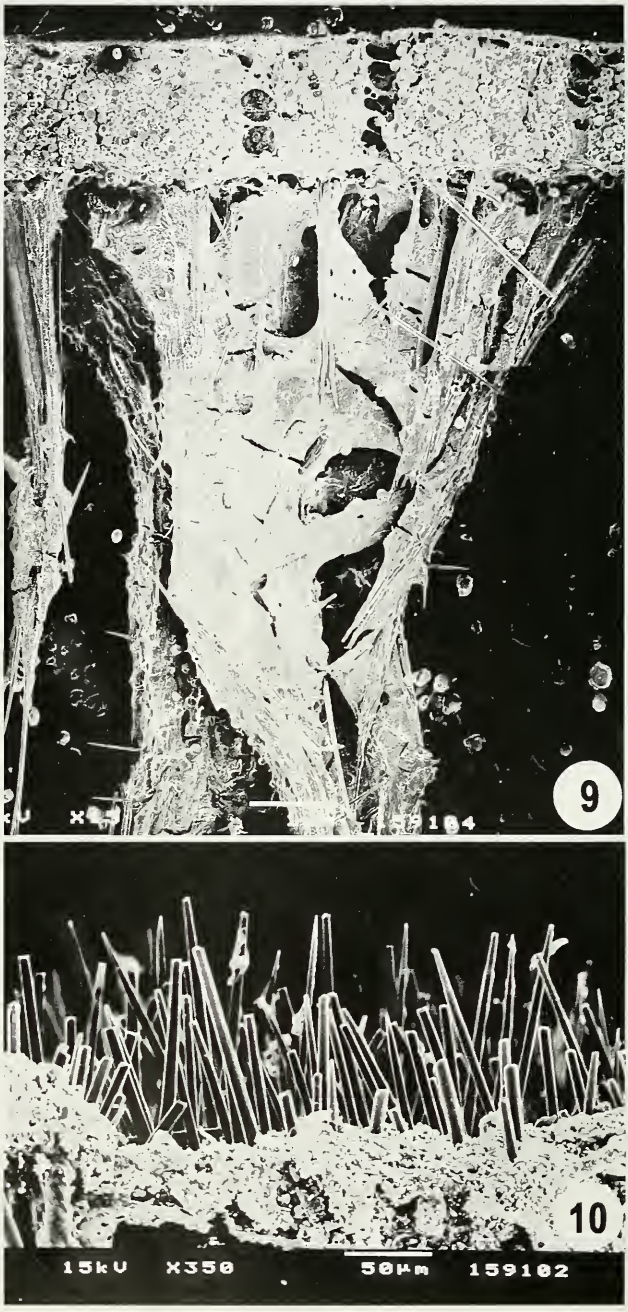
Material: Holotype MCN 2355 (schizoholotype MHNG-INVE 26565), R/V "Atlântico Sul", off Rio Grande do Sul State coast. St. 10 (32°00'S/50°00'W). 10-X-1991. 520 m. rocky bottom.

Description: Globose sponge (fig. 3). diameter 27 cm, height 24 cm. Surface smooth to the touch; single oscule, apical, central, elypsoidal, diameter 3.5/3 cm, at the



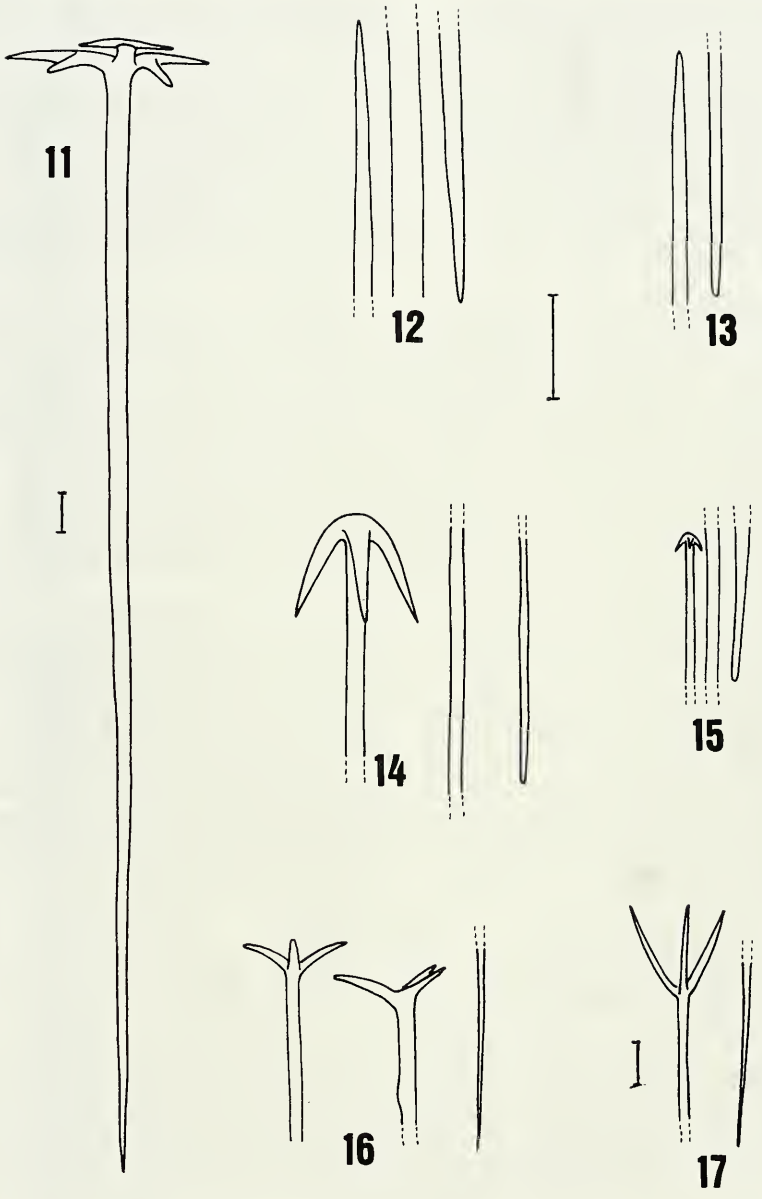
FIGS 5-8

Skeleton: 5, 6.Skeletal arrangement. 5, *Geodia australis* sp. n.; 6. *G. splendida* sp. n.; 7, 8. Sponge surface : 7, *G. australis* sp. n.; 8, *G. splendida* sp. n.



FIGS 9-10

Geodia riograndensis sp. n.: 9. skeletal architecture; 10. oxeas protracting at the sponge surface.



FIGS 11-17

Megascleres of *Geodia australis* sp. n.: 11, dichotriaene; 12, oxeas I; 13, oxea II; 14, anatriaene; 15, smaller anatriaene; 16, plagiotriaene; 17, protriaene. Scales = 100 μm.

terminal part of a cylindrical channel (length 12 cm), in the inner lateral walls of which the exhalant channel openings can be observed; pores not visible. Preserved material of violet colour and hard consistency.

Skeleton: Ectosomal (fig. 6): cortex made up of several overlaping layers of sterrasters (0.6-0.7 cm) and the discrete protraction of robust oxeas and some rare styloid forms (fig. 8); the cladomes of the orthotriaenes are placed parallel to the sponge surface just below the cortex.

Choanosomal (fig. 6): formed by the rhabdoms of the orthotriaenes, perpendicular to the surface and, among them, long oxeas, randomly distributed and rare sterrasters.

Spicules: Oxeas I (fig. 27): straight or slightly bent, robust, with ends blunt or gradually pointed, length 2254-*2681.0*-3151/ width 28-*44.2*-62 µm.

Oxeas II (fig. 30): straight or slightly curved, with gradually pointed or mucronate ends; some thinner scleres have blunt ends. Length 228-*432.7*-684 µm, width 5.7-*10.7*-19 µm.

Orthotriaenes (figs 28, 29): straigth; cladi straight or bent downward at their distal portion, with blunt or gradually sharpening ends; length 3266-*3689*.0-4094 µm, width 104-*111.6*-120 µm, cladome diameter 920-*1165.7*-1495 µm.; cladi length 437-*589.8*-759 µm, cladi width at the base 85-*100.8*-113 µm.

Sterrasters (figs 31-36): spherical or ellipsoidal, with conspicuous hilum, microspined at the outer portion (figs 34, 35); surface with rounded holes (figs. 31, 32) or conical rays (fig. 33) in young forms; or provided with regular microspinature in star shape in adult scleres (figs 34-36); diameter 95-148.2-171/86-*119.7*-152 µm.

Oxyasters I (fig. 37): 4 to 8 microspined rays all along their length; total diameter 78-*100.1*-131 µm, center 6.9-*9.2*-13.8 µm, rays 35-*46.9*-62/2.8-*4.7*-6.9 µm.

Oxyasters II (fig. 38): 4 to 9 rays provided with conical microspines all along their length, total diameter 12-*17.9*-23 µm, center 1.6-*2.3*-3.4 µm, rays length 4.6-*7.9*-11.5 µm, rays width < 1 µm.

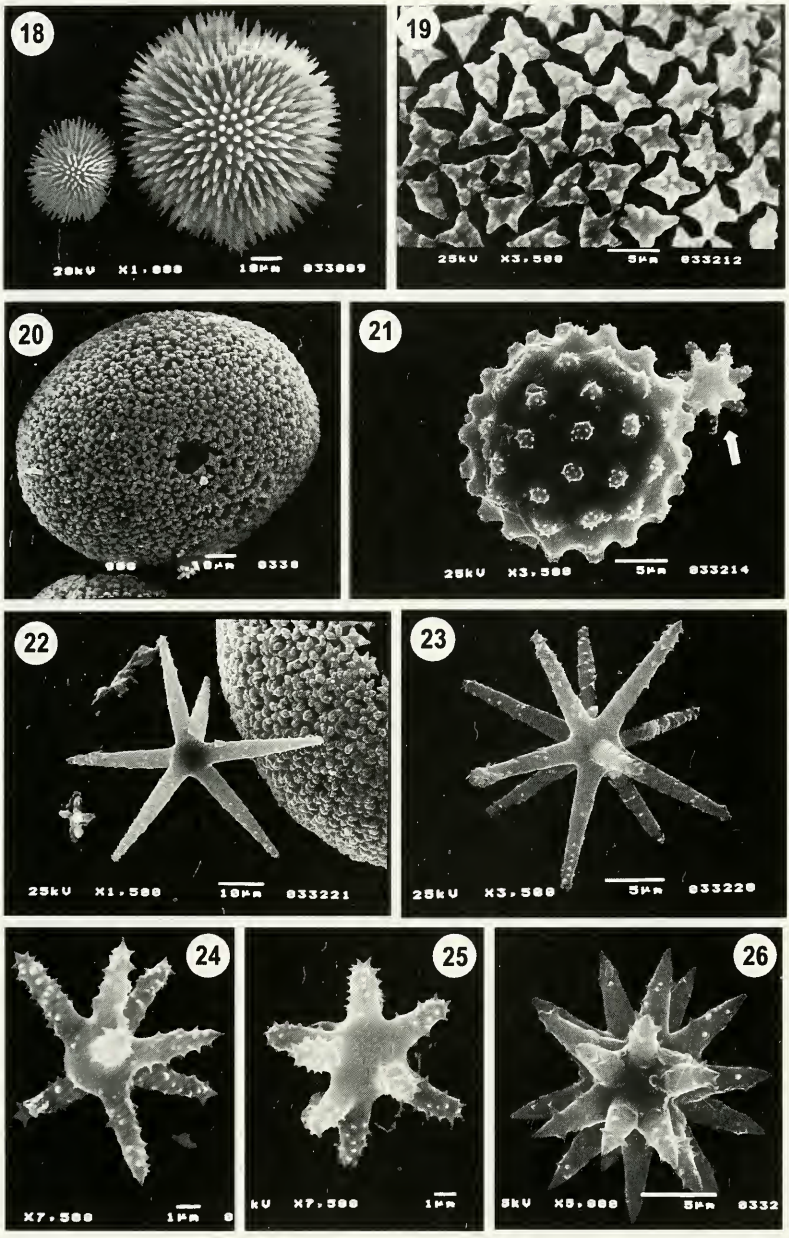
Spherostrongylasters (fig. 39): 5 to 11 microspined rays all along their length, with blunt ends, diameter 5.5-*7.4*-9.9 µm, rays 1.1-*1.5*-2.2/<1.0-1.5 µm.

Etymology: The specific name refers to the beauty and large size of the specimen. [Latin word *splendidus* = magnific]

Remarks: Geodia splendida sp. n. is close to *Geodia corticostylifera* Hajdu *et al.*, 1992 [Holotype UFRJ POR 3098 and Paratype UFRJ POR 3714, examined] by the shared presence of oxeas, orthotriaenes and oxyasters. They both differ nevertheless by the presence of an additional category of styles instead of oxeas in *G. corticostylifera* and of microscleres of the spheroxyaster and strongylospheraster types in *G. splendida* sp. n.

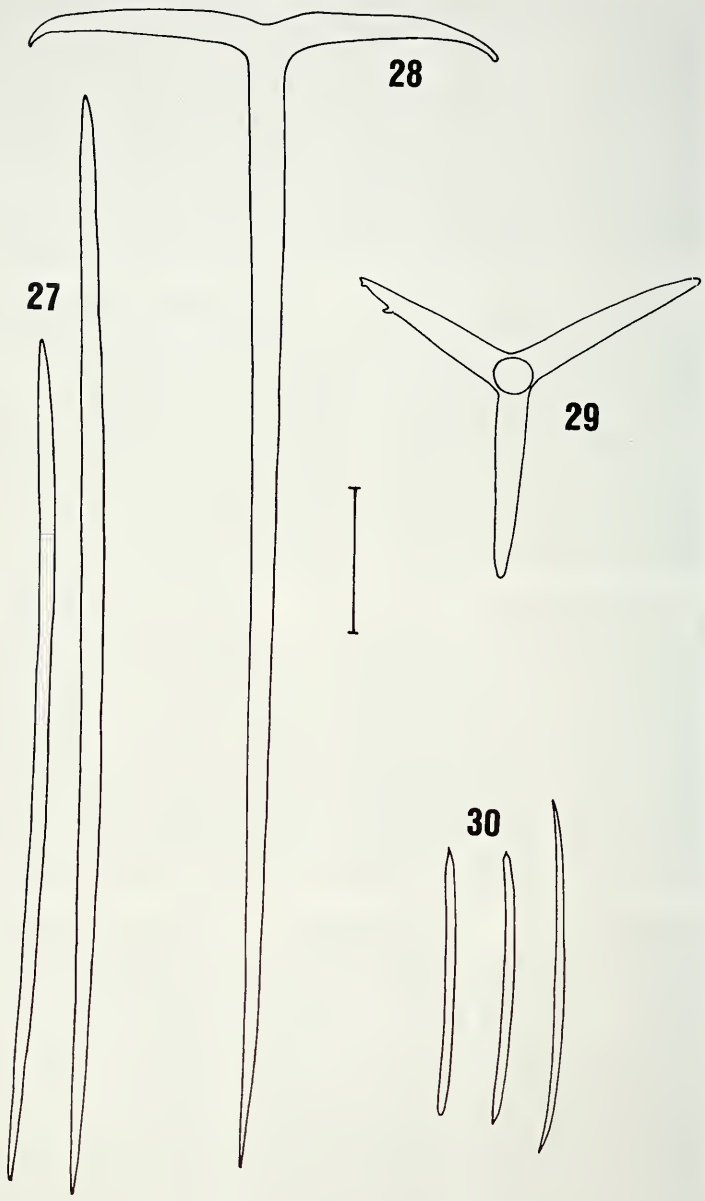
Geodia riograndensis sp. n. Figs 1, 4, 9, 10, 40-58

Material: Holotype MCN 1591 (schizoholotype MHNG-INVE 26566),"R/V Atlântico Sul", off Rio Grande do Sul State coast, St. 2-26 (31°05'S/49°31'W), 15-II-1987, 300 m, rocky substrate; Paratype MCN 3452, R/V . "Atlântico Sul", off Rio Grande do Sul State coast, St. 1-5 (32°24'55"S/50°14'85"W), 30/IV/1986, 200 m, rocky substrate.



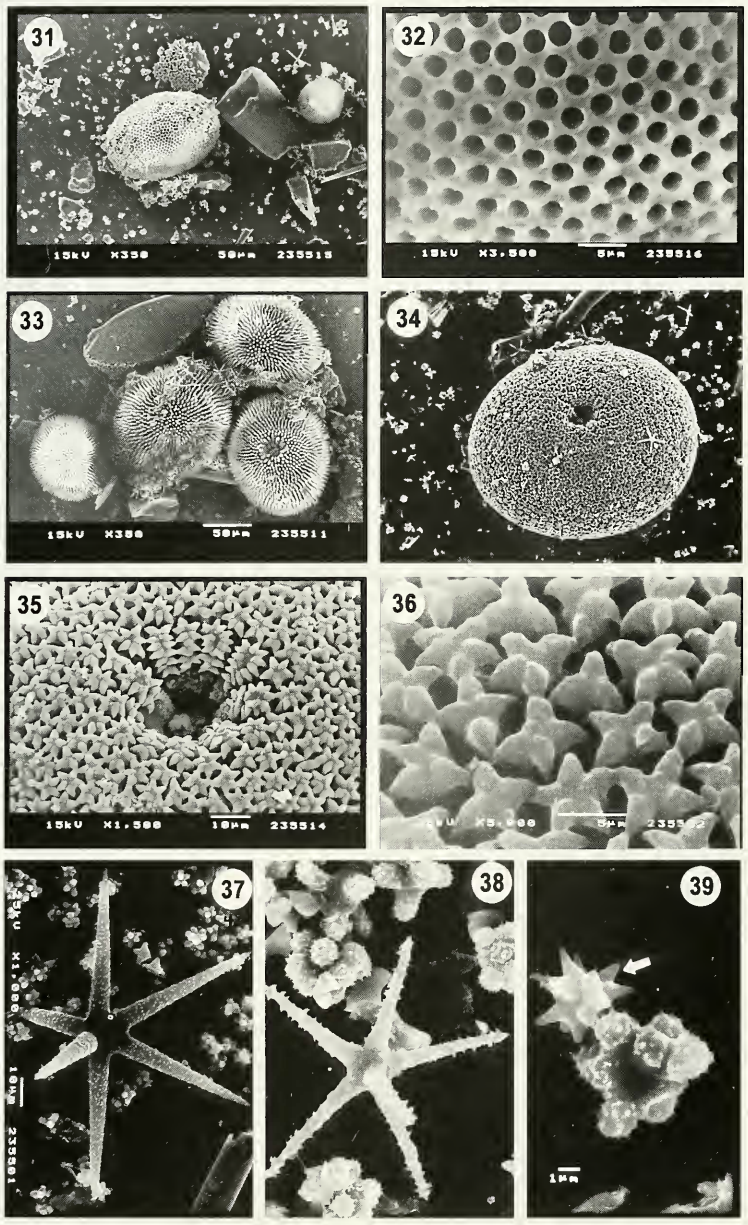
FIGS 18-26

Microscleres of *Geodia australis* sp. n.: 18, young sterraster; 19, adult sterraster surface; 20, adult sterraster with hilum; 21, spheraster and spherostrongylaster (arrow); 22, oxyaster I; 23, oxyaster II; 24, spherostrongylaster with conical tips; 25, spherostrongylaster; 26, spheroxyaster.



FIGS 27-30

Megascleres of *Geodia splendida* sp. n.: 27, oxea I; 28, orthotriaene; 29, orthotriaene cladome in apical view; 30, oxeas II. Scale = 500 μm.



FIGS 31-39

Microscleres of *Geodia splendida* sp. n.: 31, 33 sterraster developmental stage; 32, sterraster developmental stage surface; 34, adult sterraster; 35, sterraster surface with hilum; 36, adult sterraster showing microspinature details; 37, oxyaster I; 38, oxyaster II; 39, spherostrongylaster developmental stage (arrow) and grown spherostrongylaster.

Description: Subglobose fragment (fig. 4), diameter 10.6 cm, height 7.5 cm. Hispid surface, with slight brushes of oxeas (0.2-0.5 mm) (fig. 10); central oscule (diameter 11 mm), raising above the surface (3 mm), at the terminal part of a cylindric channel (length 44 mm), in the inner lateral wall of which the opening of the exhallant channels can be observed; pores were not observed. Preserved material with beige colour and firm consistency.

Skeleton: Ectosomal (fig. 9): Cortex made up by large quantities of sterrasters in regular overlapping layers, throughout which, small and thin oxeas are found and, more rarely, very long oxeas with filiform ends, both projecting slightly above the sponge surface. In the subcortical area orthotriaenes and additional categories of triaenes are distributed slant or perpendicular to the surface, the latter being hardly observed.

Choanosomal (fig. 9): formed by tracts of oxeas perpendicular to the surface and rare sterrasters of random distribution.

Spicules: Oxeas I (fig. 42): thin, sinuous, with gradually pointed ends, length 2415-*5720.5*-8464 µm, width: 12-*17.5*-23 µm.

Oxeas II (fig. 43): robust, straight or slightly curved, with blunt or mucronate ends. Some scleres thinner, with one of the ends presenting lateral conical expansions, from which one of the sclere sides becomes gradually thinner, length 1610-*2082.0*-2726 µm, width 21-*35.2*-46 µm.

Oxeas III (fig. 44): straight or slightly curved, with gradually pointed ends, length 247-*486.6*-741 µm, width 5.7-*8.9*-11.4 µm.

Orthotriaenes (figs 40, 41): straight rhabd with end conical or sharpening gradually; straight or downwards cladi with conical or strongyliform distal ends, sometimes bi- or trifurcate, length 1725-*2819.8*-3675 µm, width 44-*66.5*-92 µm, cladome diameter 575-*775.3*-989 µm, cladi length 253-*365.4*-437 µm, cladi thickness at the base 32-*55.0*-69 µm.

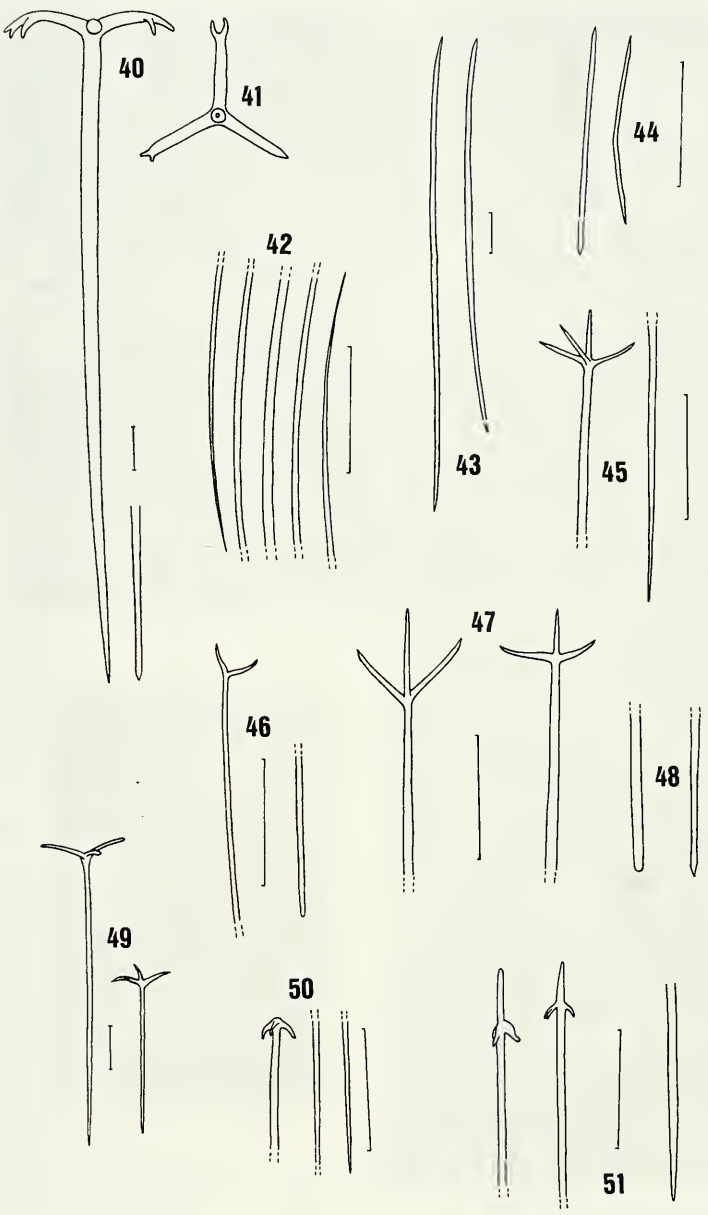
Anatriaenes (fig. 50): rare (N=6); straight rhabd with gradually pointed ends, cladi with gradually pointed or strongyliform ends, length 4501 µm, width 9.5-12.3 (m, cladome diameter 33-67 µm, cladi length 19-38 µm, cladi thickness at the base 6.6-9.5 µm.

Plagiotriaenes (fig. 49): rare (N=4); straight rhabd with gradually pointed end; cladi gradually pointed, length 1495-1886 µm, width 28-39 µm, cladome diameter 460-506 µm, cladi length: 230-253 µm, cladi thickness at the base 23-37 µm.

Protriaenes (figs 47, 48): rare (N=6), straight or slightly curved rhabd, with blunt or abruptly pointed end, length 3030-5282 µm, width: 9.5-19 µm; cladome diameter 95-204.2 µm, cladi length 62-124 µm, cladi thickness at the base 8.5-14.2 µm.

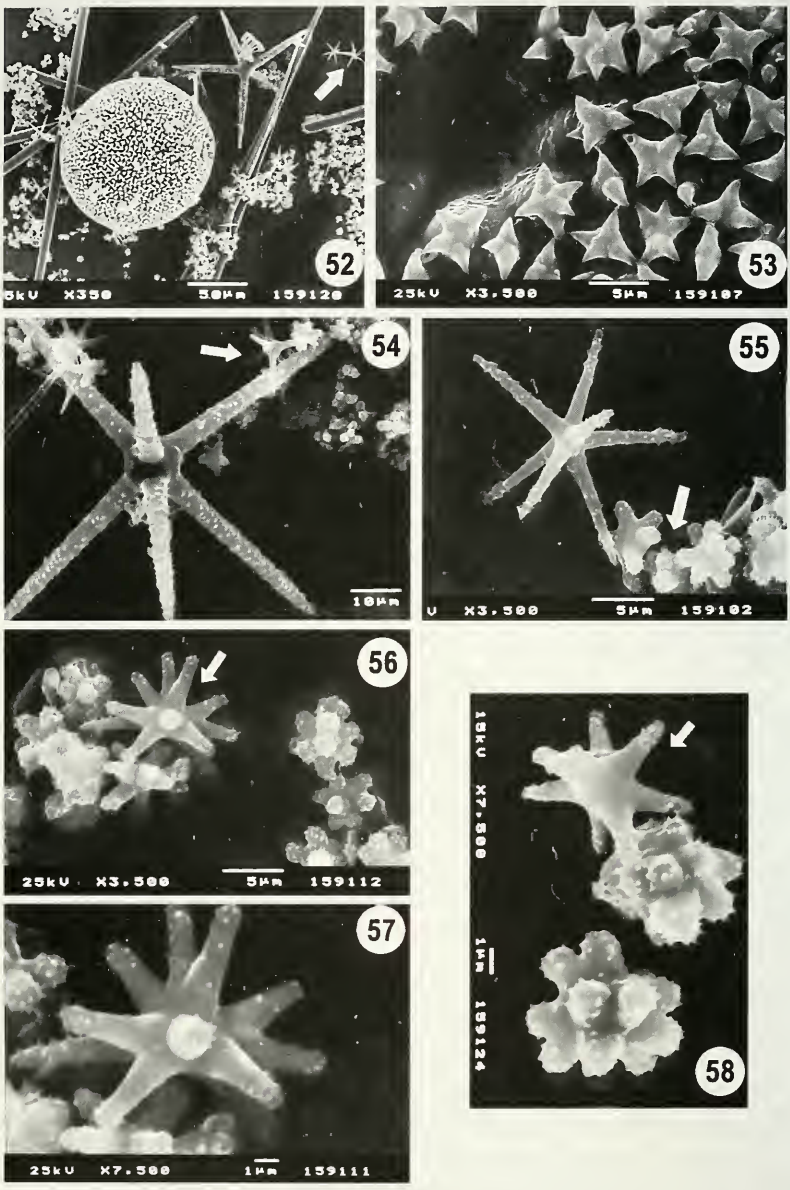
Anamesotriaenes (fig. 51). rare (N=5); straight rhabdome with abruptly pointed or strongyliform end; cladi with conical or strongyliform ends, length 5938-7581 µm, width 9.5- 14.2 µm, cladome diemeter 49-67 µm, cladi length 19-38 µm, cladi thickness at the base 6.7- 14.2 µm.

Promesotriaenes (fig. 45): rare (N=3); straight rhabdome with gradually pointed end; cladi with gradually pointed or strongyliform end, length 2484-3404 µm, width 9.5-19 µm, cladome diameter 105-190 µm, cladi length 52-105 µm, cladi thickness at the base 9.5-16.1 µm.



FIGS 40-51

Megascleres of *Geodia riograndensis* sp. n.: 40, orthotriaene; 41, orthotriaene cladome in apical view; 42, oxea I; 43, oxeas II; 44, oxeas III; 45, promesotriaene; 46, diaene; 47, protriaene; 48, protriaene basal extremity; 49, plagiotriaene; 50, anatriaene; 51, anamesotriaene. Scales = 200 μm.



FIGS 52-58

Microscleres of *Geodia riograndensis* sp. n.: 52, sterraster, oxyaster I and oxyaster II (arrow); 53, sterraster surface with hilum; 54, oxyaster I and II (arrow); 55, oxyaster II e spherostrongylaster (arrow); 56, strongylaster and spherostrongylaster (arrow); 57, strongylaster; 58, strongylaster (arrow) and spherostrongylaster.

Diaenes (fig. 46) : rare (N=2); straight or slightly sinuous rhabdome, with gradually pointed end, length 184 µm, width 17 µm, cladome diameter 200 µm, cladi length 157 µm, cladi thickness at the base 13.3 µm.

Sterrasters (figs 52, 53): spherical or oval; hilum spherical and conspicuous; surface provided with irregular microspines in form of a rosette, sometimes absent in the region around the hilum: diameter 57-*98.1*-124 µm/48-*89.9*-114 µm.

Oxyasters I (figs 52, 54): 3 to 8 microspined rays distributed along its whole length, diameter 64-*86,4*-117 µm, center: 5.7-*8.3*-11.5 µm, rays length 30-*41.9*-58 µm, rays width 2.3-*3.8*-4.6 µm.

Oxyasters II (figs 52, 54, 55): 4 to 9 microspined rays at the distal portion or, more rarely, all along their length, diameter 14-*20.2*-30 µm, center 1.8-*3.0*-4.6 µm, rays length 4.6-*9.0*-13.8 µm, rays width 1.1-*1.6*-2.3 µm.

Strongylasters (figs 56-58) - varying to spherostrongylasters (figs 55, 56, 58). 5 to 13 rays with strongyliform or truncate ends, microspined all along their length or, more rarely, at the distal half, diameter 4.6-*8.4*-13.2 µm, center 1.6-*3.2*-4.6 µm, rays length: <1.0-*3.0*-4.6/≤ 1.0 µm.

Etymology: The specific name refers to the Rio Grande do Sul State coast, off which the sponges were collected.

Remarks: When compared with other species of *Geodia* from the Brazilian coast, *Geodia riograndensis* sp. n. is close to *G. glariosa* Sollas, 1886 [Syntype BMNH 1889.1.1.86] by the shared occurrence of oxeas, ortho-, pro- and anatrienes as megascleres, differing, however, for presenting additional categories of megascleres, as three categories of oxeas, plagiotriaenes, anamesotriaenes, promesodiaenes, promesotriaenes and diaenes; and of microscleres, as oxyasters, strongylasters and strongylospherasters.

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